

DEMOCRATIZED CELLULAR NETWORK

CONNECTIVITY THROUGH SMALL CELLS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation of U.S. Patent Application No. 15/187,880, filed June 21, 2016, which claims the benefit of the filing date of U.S. Provisional Patent Application No. 62/258,128 filed November 20, 2015, the disclosure of which is hereby incorporated herein by reference.

BACKGROUND

[0002] Current small cells and femto cells provide extended coverage for a mobile operator. However, a user on a network can get access to the network only if allowed by a macro operator. This lends to an operational model where the user is tied to a macro operator and does not allow for smaller operators to provide independent service.

BRIEF SUMMARY

[0003] User Equipment (UE) or a subscriber of the UE may select a particular type of network, from a variety of available network types, to which the UE should have access.

[0004] One or more subscription profiles may be dynamically provisioned on the UE based on high-fidelity measurements and statistical data of past performance from the network. The device should determine the optimal mode of connectivity for a given position at a given time. There may be more than one simultaneous connection maintained by a device.

[0005] Connection and authentication of the UE to the network may be independent of how the user is authorized and charged for use of the network. The user may maintain multiple authorization domains, independent of the method of network attachment, that can be dynamically changed without requiring changes to credentials on the device for authentication.

[0006] The UE may transition between networks based on current network conditions. Applications on the UE may steer traffic to and from a current best network.

[0007] Local optimizations within federated access and closed mobility domains can continue to exist (e.g., intra-radio access technology (RAT) and inter-RAT mobility in long-term evolution (LTE)). However cohesiveness and mobility between unfederated network domains is achieved by connection management on the UE. The network configuration in this case resolves to a much simpler case where the networks themselves are disjoint. UEs can use small mobile operators for some types of traffic, while at the same time using local/national operators for other types of traffic.

[0008] One aspect of the disclosure provides a system, comprising a memory and one or more processors in communication with the memory. The one or more processors are configured to request periodically a list of available networks; receive periodically the list of available networks, the available networks being geo-tagged; select a first cellular network for communication through a first application, the first cellular network supported by a first evolved packet core (EPC), the first cellular network is a mobile network operator (MNO) operating with a first set of cell-selection policies set by a first owner; attach to the selected first cellular network; set up a first interface for directing traffic

through the first cellular network, the first interface being dedicated to a first IP address resulting from the attachment to the first cellular network; select a second cellular network for communication through a second application, the second cellular network being different from the first cellular network, the second cellular network supported by a second EPC different from the first EPC, the first cellular network and the second cellular network being disjoint networks, the second cellular network is a mobile virtual network operator (MVNO) operating with a second set of cell-selection policies set by a second owner; attach to the selected second cellular network, without requiring detachment from the selected first cellular network; set up a second interface for directing traffic through the second cellular network, the second interface being dedicated to a second IP address resulting from the attachment to the second cellular network; sort traffic for the first application and the second application using a flow selector, the flow selector configured to sort traffic based on criteria for sorting traffic between disjoint networks, wherein the criteria are determined based on a plurality of rules for steering traffic to disjoint networks included in a policy engine. Further, the one or more processors are configured

to steer , according to the sorting by the flow selector, a first traffic for the first application through the selected first cellular network using the first interface while remaining attached to the first cellular network and the second cellular network, and steer, according to the sorting by the flow selector, a second traffic for the second application through the selected second cellular network using the second interface while remaining attached to the first cellular network and the second cellular network. The first traffic is different from the second traffic. At least one of the selection of the first cellular network overrides the first set of cell-selection policies or the selection of the second cellular network overrides the second set of cell-selection policies.

[0009] Another aspect of the disclosure provides a method, comprising requesting periodically, with one or more processors, a list of available networks; receiving periodically, with one or more processors, the list of available networks, the available networks being geo-tagged; selecting, with the one or more processors, a first cellular network for communication through a first application, the first cellular network supported by a first evolved packet core (EPC), the first cellular network is a mobile network operator (MNO) operating with a first set of cell-selection policies set by a first owner; attaching to the selected first cellular network; setting up, with the one or more processors, a first interface for directing traffic through the first cellular network, the first interface being dedicated to a first IP address resulting from the attachment to the first cellular network. Further, the one or more processors select, with one or more processors, a second cellular network for communication through a second application, the second cellular network being different from the first cellular network, the second cellular network supported by a second EPC different from the first EPC, the first cellular network and the second cellular network being disjoint networks, the second cellular network is a mobile virtual network operator (MVNO) operating with a second set of cell-selection policies set by a second owner; attaching to the selected second cellular network, without requiring detachment from the selected first network; setting up, with the one or more processors, a second interface for directing traffic through the second cellular network, the second interface being dedicated to a second IP address resulting from the attachment to the second cellular network; sorting traffic for the first application and the second application using a flow selector, the flow selector configured to sort traffic based on criteria for sorting traffic between disjoint networks, wherein the criteria are determined based on a plurality of rules for steering traffic to disjoint networks included in a policy engine. The method further includes steering, with the one or more processors according to the sorting by the flow selector, a first traffic for the first application through the selected first cellular network using the first interface while remaining attached to the first cellular network and the second cellular network; and steering, with the one or more processors according to the sorting by the flow selector, a second traffic for the second application through the selected second cellular network using the second interface while remaining attached to the first cellular network and the second cellular network. The first traffic is different from the second traffic. At least

one of the selection of the first cellular network overrides the first set of cell-selection policies or the selection of the second cellular network overrides the second set of cell-selection policies.

[0010] Yet another aspect of the disclosure provides a user equipment, comprising a memory storing a plurality of subscription profiles, each subscription profile corresponding to a different network operator and including information for connecting to the network operator. The user equipment further includes a modem adapted to attach to multiple networks at a same time, the modem configured to periodically receive information identifying different types of available networks, and a processor in communication with the memory and the modem, the processor configured to select one of the identified available networks, based at least on the stored subscription profiles, and instruct the modem to attach to the selected network. Even further, the user equipment may include a policy engine configured to determine which network, of a plurality of networks to which the modem is attached, to use for transmitting data, the determination being based on one or more conditions associated with the data and the plurality of networks, and a flow selector in communication with the policy engine, the flow selector configured to sort the data based on the determination by the policy engine.

[0011] A further aspect of the disclosure provides a non-transitory computer-readable medium storing instructions executable by one or more processors to perform a method, comprising requesting periodically a list of available networks; receiving periodically the list of available networks, the available networks being geo-tagged; selecting a first cellular network for communication through a first application, , the first cellular network supported by a first evolved packet core (EPC), the first cellular network is a mobile network operator (MNO) operating with a first set of cell-selection policies set by a first owner; attaching to the selected first cellular network; setting up a first interface for directing traffic through the first cellular network, the first interface being dedicated to a first IP address resulting from the attachment to the first cellular network. Further, the instructions provide for selecting a second cellular network for communication through a second application, the second cellular network being different from the first cellular network, the second cellular network supported by a second EPC different from the first EPC, the first cellular network and the second cellular network being disjoint networks, the second cellular network is a mobile virtual network operator (MVNO) operating with a second set of cell-selection policies set by a second owner; attaching to the selected second cellular network, without requiring detachment from the selected first cellular network. The instructions further provide for steering, according to the sorting by the flow selector, a first traffic for the first application through the selected first cellular network using the first interface while remaining attached to the first cellular network and the second cellular network; and steering, according to the sorting by the flow selector, a second traffic for the second application through the selected second cellular network using the second interface while remaining attached to the first cellular network and the second cellular network. The first traffic is different from the second traffic. At least one of the selection of the first cellular network overrides the first set of cell-selection policies or the selection of the second cellular network overrides the second set of cell-selection policies.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Fig. 1 is a block diagram of an example system according to aspects of the disclosure.

[0013] Fig. 2 is a block diagram of another example system according to aspects of the disclosure.

[0014] Fig. 3 is a block diagram of another example system according to aspects of the disclosure.

[0015] Fig. 4 illustrates a subscription process according to aspects of the disclosure.

[0016] Fig. 5 illustrates a network discovery process according to aspects of the disclosure.

[0017] Fig. 6 illustrates an example of network attachment according to aspects of the disclosure.

CLAIMS:

1. A system, comprising:
a memory;
one or more processors in communication with the memory, the one or more processors configured to:
 - request periodically a list of available networks;
 - receive periodically the list of available networks, the available networks being geo-tagged;
 - select a first cellular network for communication through a first application, the first cellular network supported by a first evolved packet core (EPC), the first cellular network is a mobile network operator (MNO) operating with a first set of cell-selection policies set by a first owner;
 - attach to the selected first cellular network;
 - set up a first interface for directing traffic through the first cellular network, the first interface being dedicated to a first IP address resulting from the attachment to the first cellular network;
 - select a second cellular network for communication through a second application, the second cellular network being different from the first cellular network, the second cellular network supported by a second EPC different from the first EPC, the first cellular network and the second cellular network being disjoint networks, the second cellular network is a mobile virtual network operator (MVNO) operating with a second set of cell-selection policies set by a second owner;
 - attach to the selected second cellular network, without requiring detachment from the selected first cellular network;
 - set up a second interface for directing traffic through the second cellular network, the second interface being dedicated to a second IP address resulting from the attachment to the second cellular network;
 - sort traffic for the first application and the second application using a flow selector, the flow selector configured to sort traffic based on criteria for sorting traffic between disjoint networks, wherein the criteria are determined based on a plurality of rules for steering traffic to disjoint networks included in a policy engine;
 - steer, according to the sorting by the flow selector, a first traffic for the first application through the selected first cellular network using the first interface while remaining attached to the first cellular network and the second cellular network; and
 - steer, according to the sorting by the flow selector, a second traffic for the second application through the selected second cellular network using the second interface while remaining attached to the first cellular network and the second cellular network;
 - wherein the first traffic is different from the second traffic; and

wherein at least one of the selection of the first cellular network overrides the first set of cell-selection policies or the selection of the second cellular network overrides the second set of cell-selection policies.

2. The system of claim 1, wherein selecting the first cellular network is based on at least one of quality of the network connection or a cost of receiving data through the first cellular network.

3. The system of claim 1, wherein the first application is different from the second application.

4. The system of claim 3, wherein the first cellular network and the second cellular network have different associated costs.

5. The system of claim 1, wherein the first cellular network is a cellular mobile network operator (MNO) radio access network (RAN) and the first EPC is an MNO EPC, and wherein the second cellular network is a mobile virtual network operator (MVNO) for an independently operated small cell long-term evolution (LTE) network.

6. The system of claim 1, wherein the flow selector sorts traffic between the appropriate applications and networks based on one or more of: user input, network pricing, type of traffic, traffic volume, network signal strength, signal quality, statistical data, historical data, state of a user equipment, or conditions surrounding the user equipment.

7. The system of claim 1, wherein at least one of selecting the first cellular network or selecting the second cellular network is performed automatically in response to detecting the network and determining that the first application or the second application meet a predefined set of criteria.

8. The system of claim 1, wherein the policy engine is configured to receive statistical data on performance of the plurality of networks from a remote database.

9. The system of claim 1, wherein the traffic steering rules are generated in response to a condition.

10. A method, comprising:
requesting periodically, with one or more processors, a list of available networks;
receiving periodically, with one or more processors, the list of available networks, the available networks being geo-tagged;

selecting, with the one or more processors, a first cellular network for communication through a first application, the first cellular network supported by a first evolved packet core (EPC), the first cellular network is a mobile network operator (MNO) operating with a first set of cell-selection policies set by a first owner;

attaching to the selected first cellular network;

setting up, with the one or more processors, a first interface for directing traffic through the first cellular network, the first interface being dedicated to a first IP address resulting from the attachment to the first cellular network;

selecting, with the one or more processors, a second cellular network for communication through a second application, the second cellular network being different from the first cellular network, the second cellular network supported by a second EPC different from the first EPC, the first cellular network and the second cellular network being disjoint networks, the second cellular network is a mobile virtual network operator (MVNO) operating with a second set of cell-selection policies set by a second owner;

attaching to the selected second cellular network, without requiring detachment from the selected first cellular network;

setting up, with the one or more processors, a second interface for directing traffic through the second cellular network, the second interface being dedicated to a second IP address resulting from the attachment to the second cellular network;

sorting traffic for the first application and the second application using a flow selector, the flow selector configured to sort traffic based on criteria for sorting traffic between disjoint networks, wherein the criteria are determined based on a plurality of rules for steering traffic to disjoint networks included in a policy engine;

steering, with the one or more processors according to the sorting by the flow selector, a first traffic for the first application through the selected first cellular network using the first interface while remaining attached to the first cellular network and the second cellular network; and

steering, with the one or more processors according to the sorting by the flow selector, a second traffic for the second application through the selected second cellular network using the second interface while remaining attached to the first cellular network and the second cellular network;

wherein the first traffic is different from the second traffic; and

wherein at least one of the selection of the first cellular network overrides the first set of cell-selection policies or the selection of the second cellular network overrides the second set of cell-selection policies.

11. The method of claim 10, wherein selecting the first cellular network is based on at least one of quality of the network connection or a cost of receiving data through the first cellular network.

12. The method of claim 10, wherein the first application is different from the second application.

13. The method of claim 12, wherein the first cellular network and the second cellular network have different associated costs.

14. The method of claim 10, wherein at least one of selecting the first cellular network or selecting the second cellular network is performed automatically in response to detecting the network and determining that the first application or the second application meet a predefined set of criteria.

15. The method of claim 10, wherein the policy engine is configured to receive statistical data on performance of the plurality of networks from a remote database.

16. The method of claim 10, wherein the traffic steering rules are generated in response to a condition.

17. A non-transitory computer-readable medium storing instructions executable by a processor to perform a method, comprising:

- requesting periodically a list of available networks;
- receiving periodically the list of available networks, the available networks being geo-tagged;
- selecting a first cellular network for communication through a first application, the first cellular network supported by a first evolved packet core (EPC), the first cellular network is a mobile network operator (MNO) operating with a first set of cell-selection policies set by a first owner;
- attaching to the selected first cellular network;
- setting up a first interface for directing traffic through the first cellular network, the first interface being dedicated to a first IP address resulting from the attachment to the first cellular network;
- selecting a second cellular network for communication through a second application, the second cellular network being different from the first cellular network, the second cellular network supported by a second EPC different from the first EPC, the first cellular network and the second cellular network being disjoint networks, the second cellular network is a mobile virtual network operator (MVNO) operating with a second set of cell-selection policies set by a second owner;
- attaching to the selected second cellular network, without requiring detachment from the selected first cellular network;
- steering, according to the sorting by the flow selector, a first traffic for the first application through the selected first cellular network using the first interface while remaining attached to the first cellular network and the second cellular network; and

steering, according to the sorting by the flow selector, a second traffic for the second application through the selected second cellular network using the second interface while remaining attached to the first cellular network and the second cellular network;

wherein the first traffic is different from the second traffic; and

wherein at least one of the selection of the first cellular network overrides the first set of cell-selection policies or the selection of the second cellular network overrides the second set of cell-selection policies.

18. The method of claim 17, wherein selecting the first cellular network is based on at least one of quality of the network connection or a cost of receiving data through the first cellular network.

19. The method of claim 17, wherein at least one of selecting the first cellular network or selecting the second cellular network is performed automatically in response to detecting the network and determining that the first application or the second application meet a predefined set of criteria.